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To: Mike Paul, Tetra Tech
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The authors made good use of the extensive databases and literature linking eutrophication-related water quality to aesthetic qualities, recreational potential, safety, and public health. This document and supporting datasets provide a logical framework for restoring and protecting NYS lakes, as well as data and rationale that will be useful for the EPA and other states in ongoing effort to "calibrate" nutrient criteria in terms that are linked to water uses and meaningful to the public. My comments stem from experience working with similar datasets used to set criteria in other states. As an engineer having worked through TMDLs, I thought about how I would interpret the document in the process of analyzing data and developing a TMDL for a hypothetical lake in NYS. My questions and comments arose in several readings of the document and appear in no particular order.

1) The criteria are based upon aesthetics (user survey), recreational potential (user survey), safety (Secchi), and health (algal toxins). It is apparently assumed that other factors relevant to setting nutrient standards (e.g., fisheries, aquatic vegetation, periphyton, dissolved oxygen, pH, anti-degradation) are addressed separately and that "attainability" in the context of existing land uses is not a factor in setting the standards. The document should contain an explicit discussion of those assumptions.

2) *"Interpretation of AWQVs"*. This section contains the judgments, assumptions, and "fine print" that determine how the criteria will actually be applied. The algorithms are at least as important as the criteria themselves. These are apparently based upon the numeric criteria derived in previous sections and regulatory/policy considerations. Provisions based upon policy should be distinguished from those based upon the data. The structure is laid out in the flowcharts, but the associated descriptions of the rationale are in places unclear and seem inconsistent with the flow charts in some respects. Aside from the specific examples discussed below, I recommend that the entire section be systematically reviewed to ensure that the language is clear, concise, and consistent with the flowcharts. Any situations where the intent is to "over-ride" the flow charts should be clearly identified and explained.

3) Exercise of "professional judgment" is appropriate and unavoidable in specific situations. While not stated, it is assumed that the state agencies will be making the

judgments. The factors to be considered should be clearly identified and include the quantity and quality of the supporting data.

4) The flowcharts are complicated with several decision points ("if tests"), variations in numeric criteria (switching from criteria based upon aesthetics/recreation to ones based upon safety/ toxicity), and end points ("Impaired", "Stressed", "Threatened", "Fully Supporting"). Given the uncertainties and limitations in the data (one-two years), is this degree of complexity necessary/appropriate in order to accomplish the objectives? It may be appropriate to include an explicit iteration loop that would require more data to make the determination, based upon BPJ, variability in the data, etc..,

5) What happens to lakes that land in limbo ("Stressed" or "Threatened")? Are the water quality problems dismissed, addressed, or further studied? Further data collection until the issue is resolved?

6) As data are collected over the years, are the flow charts repeatedly applied and lakes reclassified? Is the compliance assessment applied to the cumulative database for each lake or just the data collected over the last 1-2 or N years? The assessment result could be insensitive to trends if the cumulative database is used.

7) Given that the methodology is applied to very limited data from each lake (one-two years) and that various assumptions were necessary in translating the numeric criteria into an implementation framework, it is likely that some lakes will be placed in the wrong boxes because of random variations in the data. It would be useful to "test" the flowcharts by applying the algorithms to the supporting lake databases. What percentage of the lakes land in each box? How do the results vary with duration of the datasets (one, two, vs. more years)? Revision of the methodology and/or data requirements may be appropriate if high percentages of the reference lakes are classified as impaired or if high percentages of lakes that are known to be impaired based upon long datasets are classified as fully supporting based upon data from one-two years.

8) *"Form of AWQVs – Recommendation = Median Value"*. I recommend using mean TP, Chl-a, and Secchi values instead of medians in determining compliance for the following reasons:

   a) Medians are insensitive to algal blooms, which are the primary management concern. For example, consider hypothetical Chl-a samples for a given year (5, 10, 20, 60, 11) with median = 11 ppb (meets 12 ppb shallow lake criterion) and mean = 21 ppb (not so). This type of variability is not uncommon in lake data. Using medians for Chl-a and TP weakens the standards considerably.

   b) I don't see anything in the criteria derivation indicating that medians are more appropriate for use in compliance assessment. Several of the tables and figures make reference to mean values. It is true that the median is closer to the true

"central tendency" for a log-normal distribution, but that is not a constraint on the compliance assessment.

c) It would be inappropriate to use the median just because it is insensitive to outliers, especially when it weakens the test significantly. Statistical outliers resulting from sampling or analytical problems would have to be considered in QA/QC and data screening protocols.

d) Existing empirical models (e.g. P loading models, Chl-a vs. TP regressions, Secchi vs. TP, Carlson TSI, etc) are all based upon mean values. These tools for TMDL development are taken away if the standards are based upon median values.

e) I am not aware of other states, countries, or scientific literature that use median chlorophyll-a or phosphorus as a basis for regulation or trophic state classifications.

9) *"Duration of AWQVs – Recommendation = One to Two Years"*. The TMDL result depends critically on the averaging time scale for the water quality standards (Walker, 2003). The TMDL expressed as a long-term average load will have to be significantly lower if the lake standard has to be met every year as opposed to long-term average. The assessment methodology is applied based on 1-2 years of data. If the TMDL is designed to meet the long-term average and the lake responds as predicted, the standards could be exceeded in 50% of the individual years. What would be the agency's requirements for TMDL modeling assumptions in that regard?

10) …*Two years is described as an "accurate" starting point for TMDL calculations.* This is a judgment call. Based upon the expected year-to-year variability in the lakes and the fact that loadings also have to be measured to support the TMDL calculations, I suggest that two years is "minimal", three years is "adequate", and neither is "accurate".

11) Will TMDL assessments be required to demonstrate that each of the numeric criteria is met? Minnesota required that the TMDLs be designed around the TP criterion. Requiring that each criterion be met would be considerably more stringent and not reflect the fact that individual lakes will have different relationships between TP and Chlorophyll-a and/or between TP and Secchi. Building the TMDL around TP is simpler because it can be linked directly to the external P load using mass-balance models.

12) *P. 21 "Although the risk assessments used to generate these criteria already provide some "safety" assurances …*". Does this mean that the standards can be assumed to already include the "Margin of Safety" required in the TMDL regulations? Otherwise, the MOS would typically be embedded in conservative modeling assumptions, conservative BMP designs, etc.

13) *Implications for CALM – Listing Triggers*, First pp: *"When all of these trophic indictors (chlorophyll a, Secchi disk transparency, total phosphorus) do not intersect, recreational use impacts may also occur, but the management of these waterbodies should not be addressed through the nutrient criteria development process"*. The term "intersect" is unclear. While we see significant correlations among these variables across lakes, they do not fall on the same regression lines or classifications based upon the numeric criteria or user surveys. Each lake has its own set of unique features that determine ecological responses and use impairments to phosphorus. Requiring that each of the variables "Intersect" (with what?) before regulating nutrients does not acknowledge that fact, uncertainties in the data, or the uncertainties in the numeric criteria.

14) P28. "Likewise, excessive nutrients may not lead to a buildup of algae, due to rapid turnover or competition from macroalgae or macrophytes". Aesthetics and water uses are impaired by excessive growth of macro-algae and macrophytes caused by high nutrient levels. Excessive periphyton and/or macrophytes are frequently observed in impoundments with high nutrient levels. Phytoplankton growth (Chl-a) may be limited by flushing ("turnover") rates under typical flow conditions, but major blooms develop in dry spells. For example, impoundments on the Assabet and Blackstone Rivers in Massachusetts are listed as impaired and subject to nutrient TMDLs for those reasons. How is this situation addressed?

15) *"Therefore, it is proposed that a "violation" of nutrient criteria usually be limited to those waterbodies in which reduced water clarity is caused by excessive algae, which in turn is caused by excessive nutrients."* Does this mean that water clarity drives the train? i.e., if the transparency criterion is met, the lake can't be listed as impaired? That logic does not come across in the flow charts. There are significant limitations of the Secchi Depth measurement as a measure of use impairment driven by nutrients. For example, have the following factors been considered in placing greater weight on the water clarity criterion?

i) Flake-forming algae that have less impact on transparency and cause surface scums that are generally not sampled for chlorophyll-a.
ii) Bluegreen blooms in metalimnion (e.g., sheltered mesotrophic ponds) with no impact on transparency but potentially toxic & objectionable when die-off occurs producing surface scums etc..
iii) Non-algal turbidity and color cloud the interpretation and relevance of the transparency measurement. I agree that a lake should not be listed based upon transparency alone if it can be shown that it is caused by color or inorganic particles.
iv) Transparency does not capture shoreline growth of periphyton and aquatic weeds potentially triggered by excessive nutrient levels.
v) Potential observer bias in transparency vs. user perception categories, as noted in the derivation of the criteria.
vi) Regardless of the QA/QC, transparency also varies with the observer, time of day, clouds, wind, etc..

16) *"For those lakes with highly elevated phosphorus concentration—more than 50% greater than the ambient phosphorus value listed in Table 3—corroborating evidence and professional judgment should be used to identify the most appropriate listing for the lake."* This seems to waive the TP criterion in lakes with high TP concentrations and leave a great deal up to professional judgment. TP is an objective measurement, the factor driving excessive production of organic matter, and directly linked to TP mass balance required for TMDL.

17) P? "Impaired = default designation for lakes deeper than water clarity guidance listed in Table 8 that exceed all AWQV's" This sentence is unclear –"deeper than water clarity guidance?".

18) *"End Points for Management…"*. This section seems to focus on allocation of wastewater discharges that discharge into lakes. Discharges to streams above lakes generally have the same impact. There is no discussion of allocating non-point sources, which drive most lake water quality problems.

19) While the deep lake criteria are ultimately based upon aesthetics and recreation (user surveys), the shallow lake criteria are ultimately based upon safety/health (transparency, toxins). Consideration of toxins significantly decreases the TP criterion for shallow lakes (from 36 to 25 ppb). Table 2 indicates that 75^{th} and 90^{th} percentile TP values in shallow reference lakes are 21 and 35 ppb in the "slightly impaired" category. It is likely that the 25 ppb criterion would be exceeded in ~20% of the reference shallow lakes and in a much higher percentage of all lakes. It is likely that BPJ will have to be applied to a high percentage of shallow lakes in general, particularly those with large watersheds. Have these factors been considered?

20) Has the distinction between natural lakes vs. impoundments been considered in developing the numeric criteria and interpretation strategies? Relatively high variability in algal responses to nutrients because of fluctuations in water residence time (blooms in dry periods).

21) The left side of the shallow lake flow chart (Fig 12) has decision points based upon whether the "median Zsd measureable". Is this the same thing as median Zsd < 2 meters? Wouldn't it be simpler to state that?

22) Recommend including an appendix with additional statistical summaries of the water quality data that were used in the derivation. Regression analyses (Chl-a vs. TP, Secchi vs. Chl-a, Secchi vs. TP) of summer-mean values for lakes in each category. These would show the range of data and be useful for modeling in TMDL development. Are the final numeric criteria values consistent with (i.e. "Intersect") the regressions derived directly from the lake data? How do they compare with published TP/Chla/Secchi relationships, e.g. as reflected in Carlson TSI? If the criteria are not consistent with the correlations, a higher percentage of the lakes could end up in the fuzzy categories (Stressed, Threatened) and BPJ would have to be applied more often in the lake assessment.

23) Be clear about how the data were initially screened; e.g. based upon sampling frequency, season, completeness (all data or just Secchi depth).

24) The definitions and cross-tab algorithms associated with Tables 2 and 3 could be clarified. Do the percentiles reflect the distributions across individual samples or across lakes (summer means)? The distinction between reference condition and reference water body could be clarified in the table titles and footnotes. Are both aesthetics vs. recreation questions addressed? How do the % classifications (right column) vary with the number of years of data used for each lake?

25) P 14 Selection of Values… "Based on the average of the mean values summarized in Tables 2 and 3". Clarify text. The average of which mean values?

26) It is remarkable that the TP, Chl-a and Secchi criteria based upon unsafe swimming conditions, nuisance blooms, and microcystins are identical (middle rows, Tables 5,6,7). Is this by coincidence or by design?

27) *P. 26 Period for Sample Collection… "migration of enriched hypolimnetic waters to the lake surface affect the characterization of the lake.."* Consideration of data from late September in deep lakes could introduce high TP values that do not have significant impact algal growth. Consider allowing BPJ on a case-by-case basis or ending the "summer" on September 15-21.

28) Sensitivity analysis – Derive criteria using subsets of the data. If not explicit, discuss and explain why sensitivity is low, unimportant, or is already addressed:
   a) Completeness of data (all three parameters paired with user perception data vs. Secchi only)
   b) Duration of data (number of years)
   c) Lay vs. professional data.
   d) Drainage/lake area ratio; controls flushing rate and assimilative capacity, likelihood that reference lakes would be flagged as impaired.
   e) Natural lakes vs. impoundments

References

Walker, W.W., Consideration of Variability & Uncertainty in Phosphorus Total Maximum Daily Loads for Lakes, Journal of Water Resources Planning & Management, ASCE, Vol. 129, No. 4, pp. 337-344, July 2003.
http://www.wwwalker.net/pdf/asce_tmdl_2003.pdf

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